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<b>(21) International Application Number:</b> PCT/DK96/00499 <b>(22) International Filing Date:</b> 29 November 1996 (29.11.96) <b>(30) Priority Data:</b> 1357/95 30 November 1995 (30.11.95) DK <b>(71) Applicant (for all designated States except US):</b> NOVO NORDISK A/S [DK/DK]; Novo Allé, DK-2880 Bagsværd (DK). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> AASLYNG, Dorrit [DK/DK]; Novo Nordisk A/S, Novo Allé, DK-2880 Bagsværd (DK). SØRENSEN, Niels, Henrik [DK/DK]; Novo Nordisk A/S, Novo Allé, DK-2880 Bagsværd (DK). RØRBÆK, Karen [DK/DK]; Novo Nordisk A/S, Novo Allé, DK-2880 Bagsværd (DK). <b>(74) Common Representative:</b> NOVO NORDISK A/S; Novo Allé, DK-2880 Bagsværd (DK).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> LACCASES WITH IMPROVED DYEING PROPERTIES  <b>(57) Abstract</b>  The present invention relates to a permanent dyeing composition comprising: a) above 0 to 1 mg enzyme protein per ml dyeing composition of microbial laccase, b) one or more dye precursor, and c) optionally one or more dye modifiers, the use of the dyeing composition for dyeing keratinous fibres, such as hair, fur, hide and wool, and a method for permanent dyeing of keratinous fibres.		

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**Title:** Laccases with improved dyeing properties

**FIELD OF THE INVENTION**

5 The present invention relates to a dyeing composition comprising a microbial laccase, the use of said dyeing composition for dyeing keratinous fibres, in particular hair, fur, hide and wool, and a method for dyeing keratinous fibres.

10 **BACKGROUND OF THE INVENTION**

It has been used for many years to dye the hair to cover appearing grey hair. The need to do so arises from the fact that grey hair is the first sign of having past adolescence, which can be hard to accept for many people.

15 For instance, in certain parts of Asia it is widely used by both men and women to dye the hair with dyes often referred to by humorous people as "black shoe polish".

During the last few decades hair dyeing has become more and more popular in the western world. At first Punk Rockers and other society critical groups dyed their hair in extreme colours as a part of their protest against the established society, but today especially many young people also uses hair dyes (in more soft tints than the Punk Rockers) as a sort of "cosmetic" to change or freshen up their "look".

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Hair dyes

In general hair dyeing compositions on the market today can be divided into three main groups:

- temporary hair dyes,
- 30 - semi-permanent hair dyes, and
- permanent oxidative hair dyes.

The temporary hair dyes are only intended to change the natural hair colour for a short period of time and usually functions by depositing dyes on the surface of the hair. Such hair dyes are easy to remove with normal shampooing.

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When using semi-permanent hair dyes the colour of the dyed hair can survive for five or more shampoos. This is achieved

by using dyes having a high affinity for hair keratin and which is able to penetrate into the interior of the hair shaft.

Permanent hair dyes are very durable to sunlight, shampooing and other hair treatments and need only to be refreshed once a month as new hair grows out. With these dyeing systems the dyes are created directly in and on the hair. Small aromatic colourless dye precursors (e.g. p-phenylene-diamine and o-aminophenol) penetrate deep into the hair where said dye precursors are oxidised by an oxidising agent into coloured polymeric compounds. These coloured compounds are larger than the dye precursors and can not be washed out of the hair.

By including compounds referred to as modifiers (or couplers) in the hair dyeing composition a number of hair colour tints can be obtained. Cathecol and Resorcinol are examples of such modifiers.

Traditionally  $H_2O_2$  is used as the oxidizing agent (colour builder), but also as a bleaching agent. Dyeing compositions comprising  $H_2O_2$  are often referred to as "lightening dyes" due to this lightening effect of  $H_2O_2$ .

The use of  $H_2O_2$  in dyeing compositions have some disadvantages as  $H_2O_2$  damages the hair. Further, oxidative dyeing often demands high pH (normally around pH 9-10), which also inflicts damage on the hair and on the skin. Consequently, if using dye compositions comprising  $H_2O_2$  it is not recommendable to dye the hair often.

To overcome the disadvantages of using  $H_2O_2$  it has been suggested to use oxidation enzymes to replace  $H_2O_2$ .

US patent no. 3,251,742 (Revlon) describes a method for dyeing human hair by dye formation *in situ* (i.e. on the hair). An oxidative enzyme is used to the colour formation reactions at a substantially neutral pH (7-8.5). Laccases, tyrosinases, polyphenolases and catacolases are mentioned as suitable oxidation enzymes. The only exemplified oxidation enzyme is tyrosinase.

EP patent no. 504.005 (Perma S.A.) concerns dyeing compositions for keratinous fibres, in particular hair, which do not require the presence of  $H_2O_2$  (hydrogen peroxide). The

composition comprises an nzyme capable of catalysing the formation of the polymeric dyes and also dye precursors, such as bases and couplers, in a buffer solution wherein the pH of said composition is between 6.5 and 8 and said enzyme has an  
5 optimal activity in the pH range between 6.5 and 8.

*Rhizoctonia praticola* laccase and *Rhus vernicifera* laccase are the only laccases exemplified in the patent.

Abstract of Papers American Chemical Society vol. 209, no. 1-2, 1995 discloses the cloning of laccases from *Scytalidium*  
10 *thermophilum* and *Myceliophthora thermophila*. The abstract does not mention the use of said laccases for dyeing.

#### SUMMARY OF THE INVENTION

The object of the present invention is to provide improved  
15 dyeing compositions for keratinous fibres, such as hair, fur hide and wool, comprising an oxidative enzyme as the oxidising agent.

In the context of the present invention an "improved" composition for dyeing keratinous fibres means a composition  
20 being capable of dyeing the keratinous fibres in question faster or by the use of a smaller amount of oxidation enzyme to obtain an optimal dyeing effect, determined as  $\Delta E^*$ , in comparison to corresponding prior art dyeing compositions.

Further, it is also possible to use a less amount of dye  
25 precursor. This is advantageous as certain dye precursors are very unhealthy and very carcinogenic.

Compositions capable of dyeing the keratinous fibres, in particular hair, fur, hide and wool, faster are desirable as such compositions are very user convenient.

30 Further, it is desirable to be able to use a less amount of enzyme in the dyeing composition. This might make the dyeing process more economical. Further, the risk for creating airborne protein aerosols is reduced.

It has now surprisingly been found that it is possible to  
35 provide such improved dyeing compositions for keratinous fibres by using microbial laccases for oxidising the dye precursor(s).

Laccases (benzenediol:oxygen oxidoreductases) (E.C. class

1.10.3.2 according to Enzyme Nomenclature (1992) Academic Press, Inc.) are multi-copper containing enzymes that catalyse the oxidation of phenols. Laccase-mediated oxidation results in the production of aryloxy-radical intermediates from suitable phenolic substrates; the ultimate coupling of the intermediates so produced provides a combination of dimeric, oligomeric, and polymeric reaction products. Certain reaction products may be used to form dyes suitable for dyeing keratinous fibres, such as hair and wool (see below).

10 Firstly, the object of the invention is to provide a dyeing composition comprising

a) above 0 to 1 mg enzyme protein per ml dyeing composition of microbial laccase,

b) one or more dye precursors,

15 c) optionally one or more modifiers.

Specifically contemplated is laccases of microbial origin, derived from a strain of the genus *Myceliophthora*.

In the second aspect the invention relates to the use of a dyeing composition of the invention for dyeing keratinous fibres, such as hair, fur, hide and wool.

20 The invention also related to a method for dying keratinous fibres comprising contacting the dyeing composition of the invention to the keratinous fibres in question under suitable conditions and for a period of time sufficient to permit oxidation of the dye precursor into a coloured compound.

25 The invention also relates to the use of a laccase for permanent dyeing of keratinous fibres wherein said laccase is a laccase that results in a  $\Delta E^*$ -value higher than the  $\Delta E^*$ -value resulting from a laccase derived from *Rhus* under corresponding dyeing conditions.

30 This means that when dyeing keratinous fibres with a dyeing composition of the present invention the  $\Delta E^*$ -value determined are higher than the  $\Delta E^*$ -value determined from corresponding keratinous fibres dyed under the same conditions using a dyeing composition comprising a laccase derived from *Rhus*.

35 The term "corresponding dyeing conditions" means under conditions where e.g. the enzyme concentration or enzyme

activity, dyeing incubations time, dyeing incubation temperature, pH conditions, keratin fibre type (such as hair type) are the same, and further that the same dye precursor(s) and modifier(s) are used. In other words it defines conditions parallel to the specific dyeing conditions chosen. The dyeing conditions described below in the Examples may be chosen.

In the context of the present invention a "higher"  $\Delta E^*$  value defines that the total quantitative colour change is more than one  $\Delta E^*$  unit.

10  $\Delta E^*$  is calculated from the values of the parameters  $a^*$ ,  $b^*$  and  $L^*$  determined e.g. on a Minolta CR200 Chroma Meter using the formula  $\Delta E^* = \sqrt{(\Delta L^*^2 + \Delta a^*^2 + \Delta b^*^2)}$ . The meaning of  $a^*$ ,  $b^*$  and  $L^*$  is explained below in the "Materials and Methods" section.

#### 15 BRIEF DESCRIPTION OF THE DRAWING

Figure 1 shows the dyeing effect of six different laccases. The six laccases are the *Polyporus pinsitus* laccase (rPp-laccase), *Myceliophthora thermophila* laccase (Mt-laccase wt.), *Myceliophthora thermophila* T1 variant laccase (Mt-laccase (var)), *Rhus vernicifera* laccase (Rvl-FXu-1), *Scytalidium thermophilum* laccase (rStL-FXu-1) and *Rhizoctonia solani* laccase (rRsL-3-FXu-1). o-aminophenol is used as the dye precursor and m-phenylene-diamine is used as a modifier.

25 Figure 2 shows the wash stability of the *Myceliophthora thermophila* T1 variant laccase (Mt-laccase (var)) and the *Polyporus pinsitus* laccase (rPp-laccase) as the oxidising agent.

30 Figure 3 shows the fastness (speed) of hair dyeing using the *Myceliophthora thermophila* T1 variant laccase (Mt-laccase (var)) and the *Polyporus pinsitus* laccase (rPp-laccase) as the oxidising agent.

Figure 4 shows the dose-response dyeing effect of *Myceliophthora thermophila* laccase, using from 0.0001 to 0.5 mg enzyme protein per ml dyeing composition.

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**DETAILED DESCRIPTION OF THE INVENTION**

The object of the present invention is to provide improved dyeing compositions for permanent dyeing of keratinous fibres, such as hair, fur, hide and wool, comprising an oxidation enzyme.

It has now surprisingly been found that it is possible to provide such improved dyeing compositions by using a microbial laccase for oxidising the dye precursor(s).

**The Dyeing Composition**

In the first aspect the present invention relates to a dyeing composition comprising

- a) above 0 to 1 mg enzyme protein per ml dyeing composition of microbial laccase,
- b) one or more dye precursor, and
- c) optionally one or more dye modifiers.

In a preferred embodiment of the invention the laccase may be present in the dyeing compositions in a concentration within the range from 0.0001 to 1 mg/ml, preferably 0.001 to 0.8 mg/ml, more preferred 0.002 to 0.5, even more preferred 0.003 to 0.2, especially 0.004 to 0.1 mg enzyme protein/ml dyeing composition.

When dyeing with a composition of the invention for permanent dyeing the  $\Delta E^*$ -value obtained is higher than that obtained when using a dyeing composition comprising a laccase derived from *Rhus* under corresponding dyeing conditions.

An example of a *Rhus* laccase is the laccase derived from the Japanese varnish tree *Rhus vernicifera* (Yoshida, (1883), J. Chem. Soc., 472). The *Rhus vernicifera* laccase is used in the Example 1 below.

The microbial laccase used according to the invention is of fungal or bacteria origin, in particular of filamentous fungus origin.

In an embodiment of the invention the microbial laccase is derived from a strain of genus *Myceliophthora*, such as a strain of the species *Myceliophthora thermophila* e.g. the purified laccase described in WO 95/33836 (PCT/US95/06815) from Novo



Nordisk, which is hereby incorporated by reference. SEQ ID NO 1 below shows a DNA sequence encoding a suitable laccase derivable from *Myceliophthora thermophila*.

5 *E. coli* JM101 containing the expression vector pRaMB5 comprising SEQ ID NO 1 has been deposited under the Budapest Treaty with the Agricultural Research Service Patent Culture Collection, Northern Regional Research Center, 1815 University Street, Peoria, Illinois, 61604. The vector have been given the Accession Number NRRL B-21261.

10 Also contemplated according to the invention are laccases derived from other micro-organisms being more than 80% homologous to SEQ ID NO 1 derived from *Myceliophthora thermophila*.

In addition, *Myceliophthora* laccases also encompass alternative forms of laccases which may be found in *M. thermophila* and  
15 as well as laccases which may be found in other fungi which are synonyms of fall within the definition of *M. thermophila* as described by Apinis (Nova Hedwigia 5, 57-78, 1963) and named *Sporotrichum thermophile*. Subsequent taxonomic revisions have placed this organism in the genus *Chrysosporium* (Von Klopotek,  
20 A. Arche., (1974) Microbiol, 98, 365-369) and later *Myceliophthora* (Van Oorshot, Persoonia, (1977), 9, 401-408). A number of organisms known by other named also appear to belong to this species. These include *Sporotrichum cellulophilum* (US patent no. 4,106,989); *Thielavia thermophila* (Fergus and Sinden  
25 (1968), Can. J. Botany, 47, 1635-1637); *Chrysosporium fergusi* and *Corynascus thermophilus* (Von Klopotek, supra).

Also the use of laccase variants are contemplated according to the present invention.

30 An example of a laccase variant is the *Myceliophthora thermophila* T1 variant described in PCT/US96/14087 (Novo Nordisk).

T1 variants (or Type I variants) are modified blue copper oxidases, including laccases. T1 variants can for instance be constructed by site-directed mutagenesis and differ from the corresponding wild-type blue copper oxidases by at least one  
35 amino acid residue in the Type I (T1) copper site. These modifications generally result in altered pH profiles and/or specific activity relatively to the wild-type enzymes. This can

be advantageous when using the enzyme in question in dyeing compositions.

More specific the *Myceliophthora thermophila* T1 laccase variant may comprise the sequence 509VSGGL511 or may be modified as to increase the negative charge in at least one segment of the T1 copper site.

The above mentioned microbial laccases may advantageously be used in permanent dyeing composition for keratinous fibres. Such compositions have a superior dyeing effect to corresponding compositions comprising e.g. the *Rhus vernicifera* laccase as shown in Example 1.

The *Myceliophthora thermophila* T1 variant laccase is more wash stable and further dyes faster than the *Polyporus pinsitus* laccase which is proven in Example 2 and Example 3, respectively.

Example 4 shows that less *Myceliophthora* laccase activity (i.e. LACU/ml) is needed to obtain a suitable dyeing effect in comparison to the *Polyporus pinsitus* laccase.

Example 5 shows that for the *Myceliophthora thermophila* laccase the dyeing effect optimum is obtained around 0.005 mg enzyme protein per ml dyeing composition.

In the case of using a *Myceliophthora* laccase in a permanent dyeing composition it may advantageously be present in concentrations from above 0 to 1 mg/ml, preferably 0.0001 to 0.1 mg/ml, more preferably 0.0005 to 0.05 mg/ml, especially 0.001 to 0.01 mg enzyme protein per ml dyeing composition.

It is to be understood that the laccase may be produced either homologously, or heterologously in a host cell such as filamentous fungus, yeast or bacteria.

Examples of filamentous fungi host cells include strains of the species of *Trichoderma*, preferably a strain of *Trichoderma harzianum* or *Trichoderma reesei*, or a species of *Fusarium*, or a species of *Aspergillus*, most preferably *Aspergillus oryzae* or *Aspergillus niger*, or yeast cells, such as e.g. a strain of *Saccharomyces*, in particular *Saccharomyces cerevisiae*, *Saccharomyces kluyveri* or *Saccharomyces uvarum*, a strain of *Schizosaccharomyces* sp., such as *Schizosaccharomyces pombe*, a

strain of *Hansenula* sp., *Pichia* sp., *Yarrowia* sp., such as *Yarrowia lipolytica*, or *Kluyveromyces* sp., such as *Kluyveromyces lactis*, or a bacteria, such as gram-positive bacteria such as strains of *Bacillus*, such as strains of *B. subtilis*, *B. Licheniformis*, *B. lentus*, *B. brevis*, *B. stearothermophilus*, *B. alkalophilus*, *B. amyloliquefaciens*, *B. coagulans*, *B. circulans*, *B. lautus*, *B. megaterium* or *B. thuringiensis*, or strains of *Streptomyces*, such as *S. lividans* or *S. murinus*, or gram-negative bacteria such as *Escherichia coli*.

10 To obtain dyeing of the keratinous fibres the dyeing composition of the invention comprises one or more dye precursors which is(are) converted into coloured compound(s) by an oxidation agent which according to the present invention is a microbial laccase.

15 Without being limited thereto the dye precursor(s) may be (an) aromatic compound(s) belonging to one of three major chemical families: the diamines, aminophenols (or aminonaphtols) and the phenols. Examples of isatin derivative dye precursors can be found in DE 4,314,317-A1. Further, a number  
20 of indole or indoline derivative dye precursors are disclosed in WO 94/00100. Said dye precursors mentioned in these documents are hereby incorporated herein by reference.

Examples of suitable dye precursors include compounds from the group comprising p-phenylene-diamine (PPD), p-toluylene-diamine (PTD), chloro-p-phenylene-diamine, p-aminophenol, o-aminophenol, 3,4-diaminotoluene, 2-methyl-1,4-diaminobenzene, 4-methyl-o-phenylenediamine, 2-methoxy-p-phenylenediamine, 2-chloro-1,4-diamino-benzene, 4-amino diphenylamine, 1-amino-4- $\beta$ -methoxyethylamino-benzene, 1-amino-4-bis-( $\beta$ -hydroxyethyl)-aminobenzene, 1-3-diamino-benzene, 2-methyl-1,3-diamino-benzene, 2,4-diaminotoluene, 2,6-diaminopyridine, 1-hydroxy-2-amino-benzene, 1-hydroxy-3-amino-benzene, 1-methyl-2-hydroxy-4-amino-benzene, 1-methyl-2-hydroxy-4- $\beta$ -hydroxyethylamino-benzene, 1-hydroxy-4-amino-benzene, 1-hydroxy-4-methylamino-benzene, 1-methoxy-2,4-diamino-benzene, 1-ethoxy-2,3-diamino-benzene, 1- $\beta$ -hydroxyethyloxy-2,4-diamino-benzene, phenazines, such as 4,7-

phenazinedicarboxylic acid, 2,7-phenazinedicarboxylic acid, 2-phenazinecarboxylic acid, 2,7-diaminophenazine, 2,8-diaminophenazine, 2,7-diamino-3,8-dimethoxyphenazine, 2,7-diamino-3-methoxyphenazine, 2,7-diamino 3-methoxyphenazine, 3-dimethyl

5 2,8-phenazinediamine, 2,2'-[(8-amino-7-methyl-2-phenazinylo)imino]bis-ethanol, 2,2'-[(8-amino-7-methoxy-2-phenazinylo)imino]bis-ethanol, 2,2'-[(8-amino-7-chloro-2-phenazinylo)imino]bis-ethanol, 2-[(8-amino-7-methyl-2-phenazinylo)amino]-ethanol, 2,2'-[(8-amino-2-phenazinylo)imino]bis-ethanol, 3-amino-7-(diethylamino)-

10 thylamino)-2,8-dimethyl-5-phenyl-chloride, 9-(diethylamino)-benzo[a]phenazine-1,5-diol, N-[8-(diethylamino)-2-phenazinylo]-methanesulfonamide, N-(8-methoxy-2-phenazinylo)-Methanesulfonamide, N,N,N',N'-tetramethyl-2,7-phenazinediamine, 3,7-dimethyl-2-phenazinamine, p-amino benzoic acids, such as p-amino

15 benzoic acid ethyl, p-amino benzoic acid glycerid, p-amino benzoic acid isobutyl, p-dimethylamino benzoic acid amil, p-dimethylamino benzoic acid octyl, p-diethoxy amino benzoic amil, p-dipropoxy amino benzoic acid ethyl, acetylsalicylic acid, isatin derivatives, such as 2,3-diamino benzoic acid.

20 In an embodiment the laccase is used with the dye precursor directly to oxidise it into a coloured compound. The dye precursor may be used alone or in combination with other dye precursors.

It is believed that when using a diamine or an aminophenol

25 as the dye precursor at least one of the intermediates in the co-polymerisation must be an ortho- or para-diamine or aminophenol. Examples of such are found below and are also described in US patent no. 3,251,742 (Revlon), the contents of which are incorporated herein by reference.

30 Optionally dyeing compositions (especially hair dyeing compositions) of the invention also comprise a modifier (coupler) by which a number of colour tints can be obtained.

In general modifiers are used in dyeing composition for hair as the hair colours resulting from hair dyeing compositions

35 without modifier(s) are usually unacceptable for most people.

Modifiers are typically m-diamines, m-aminophenols, or polyphenols. Upon the optional addition of a modifier (coupler) it

reacts with the dye precursor(s) in the presence of e.g. a laccase, converting the dye precursor(s) into a coloured compound.

Examples of modifiers (couplers) include m-phenylene-diamine, 2,4-diaminoanisole, 1-hydroxynaphthalene( $\alpha$ -naphthol), 1,4-dihydroxybenzene(hydroquinone), 1,5-dihydroxynaphthalene, 1,2-dihydroxybenzene(pyrocatechol), 1,3-dihydroxybenzene (resorcinol), 1,3-dihydroxy-2-methylbenzene, 1,3-dihydroxy-4-chlorobenzene(4-chlororesorcinol), 1,2,3-trihydroxybenzene, 1,2,4-trihydroxybenzene, 1,2,4-trihydroxy-5-methylbenzene, 1,2,4-trihydroxytoluene.

When using the dyeing compositions of the invention a reduced amount of enzyme (i.e. mg enzyme protein per ml dyeing composition) is needed to obtain the maximal dyeing effect (See Figure 1 and Figure 4), determined as the optimal  $\Delta E^*$ -value, in comparison to prior art dyeing compositions, such as dyeing compositions comprising a laccase derived from *Rhus*.

The amount of dye precursor(s) and other ingredients used in the composition of the invention are in accordance with usual commercial amounts.

According to the invention the product comprising the dyeing composition may be a one or a two compartment product. In the one compartment product the laccase, the dye precursor(s) and other ingredients are kept together in a stabilised solution or kept under stable conditions (i.e. the dye precursors are not oxidised by the laccase). In a two compartment product the laccase and the dye precursor(s) and other ingredients are kept in two containers kept apart. The contents of said containers are mixed immediately before use.

### 30 USE

In the second aspect the invention relates to the use of the dyeing composition of the invention for permanent dyeing of keratinous fibres, in particular hair, fur, hide and wool.

When using a dyeing composition of the invention the  $\Delta E^*$ -value obtained is higher than that of a dyeing composition comprising a laccase derived from genus *Rhus* under corresponding dyeing conditions (see Figure 1).

### Method

In the third aspect the invention relates to a method for permanent dyeing of keratinous fibres comprising contacting a dyeing composition of the invention with the keratinous fibres in question under suitable conditions and for a period of time sufficient to permit oxidation of the dye precursor into a coloured compound.

The dyeing procedure may be carried out at room temperature, preferably around the optimal temperature of the enzyme, typically with from 10 to 60°C; at a pH in the range from 3 to 10, preferably 5 to 9, especially 6 to 8; for a period of time between 10 and 60 minutes, preferably 15 to 50 minutes, especially 20 to 40 minutes.

When using the method of the invention the  $\Delta E^*$ -value obtained is higher than that of corresponding methods where a laccase derived from a strain of the genus *Rhus* are used under the same dyeing conditions, in the presence or absence of at least one modifier, with at least one dye precursor, for a period of time, and under conditions sufficient to permit oxidation of the dye precursor used for oxidising the dye.

The method can be conducted with one or more dye precursors, either alone or in combination with one or more modifiers.

### **MATERIALS AND METHODS**

#### **25 Materials:**

##### Hair:

6" De Meo Virgin Natural White Hair (De Meo Brothers Inc. USA)

##### Enzymes:

*Myceliophthora thermophila* laccase described in WO 95/33836 (PCT/US95/06815) from Novo Nordisk Biotech, Inc.

*Myceliophthora thermophila* T1 variant laccase described in US patent application 60/003,142 from Novo Nordisk Biotech, Inc.

*Polyporus pinsitus* laccase described in WO 96/00290 (PCT/US95/07536) from Novo Nordisk Biotech, Inc.

35 *Rhus vernicifera* laccase (Yoshida, J. Chem. Soc., 472 (1883)

*Rhizoctonia solani* laccase described in WO 95/07988 from Novo Nordisk Biotech, Inc.

*Scytalidium thermophilum* laccase described in WO 95/33837 (PCT/US95/06816) from Novo Nordisk Biotech, Inc.

Deposit of Biological Material

- 5     The following biological material has been deposited on the  
25 May 1994 under the terms of the Budapest Treaty with the  
Agricultural Research Service Patent Culture Collection,  
Northern Regional Research Center, 1815 University Street,  
Peoria, Illinois, 61604 and given the following accession  
10   number.

Deposit

Accession Number

*E. coli* JM101 containing pRAMB5

NRRL B-21261

15   Dye precursors:

- 0.1 % w/w p-phenylene-diamine in 0.1 M K-phosphate buffer, pH  
7.0. (pPD)  
0.1 % w/w p-toluylene-diamine in 0.1 M K-phosphate buffer, pH  
7.0.  
20   0.1 % w/w chloro-p-phenylenediamine in 0.1 M K-phosphate  
buffer, pH 7.0.  
0.1 % w/w p-aminophenol in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w o-aminophenol in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w 3,4-diaminotoluene in 0.1 M K-phosphate, buffer pH  
25   7.0.

Modifiers:

- 0.1 % w/w m-phenylenediamine in 0.1 M K-phosphate buffer, pH  
7.0.  
30   0.1 % w/w 2,4-diaminoanisole in 0.1 M K-phosphate buffer, pH  
7.0.  
0.1 % w/w alpha-naphthol in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w hydroquinone in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w pyrocatechol in 0.1 M K-phosphate buffer, pH 7.0.  
35   0.1% w/w resorcinol in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w 4-chlororesorcinol in 0.1 M K-phosphate buffer, pH  
7.0.

The dye precursor is combined with one of the above indicated modifiers so that the final concentration in the dyeing solution is 0.1 % w/w with respect to precursor and 0.1 % w/w with respect to modifier.

5

Other solutions:

Commercial shampoo

Equipment:

10 Minolta CR200 Chroma Meter

Determination of Laccase Activity (LACU)

Laccase activity is determined from the oxidation of syringaldazin under aerobic conditions. The violet colour produced is photometered at 530 nm. The analytical conditions are 19 mM syringaldazin, 23.2 mM acetate buffer, pH 5.5, 30°C, 1 min. Reaction time.

1 laccase unit (LACU) is the amount of enzyme that catalyses the conversion of 1.0 micromole syringaldazin per minute at these conditions.

20

Assessment of the hair colour

The quantitative colour of the hair tresses is determined on a Minolta CR200 Chroma Meter by the use the parameters L\* ("0"=black and "100"=white), a\* ("-"=green and "+"=red) and b\* ("-" blue and "+" yellow).

25

$\Delta L^*$ ,  $\Delta a^*$  and  $\Delta b^*$  are the delta values of L\*, a\* and b\* respectively compared to L\*, a\* and b\* of untreated hair (e.g.  $\Delta L^* = L^*_{\text{sample}} - L^*_{\text{untreated hair}}$ ).

$\Delta E^*$  is calculated as  $\Delta E^* = \sqrt{(\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})}$  and is an expression for the total quantitative colour change.

30

**EXAMPLES**

35 

**Example 1**

Dyeing effect



The dyeing effect of different laccases were tested and compared under the same conditions using 0.1% w/w o-aminophenol (dye precursor) and 0.1% w/w m-phenylene-diamine (modifier).

The laccases tested were

- 5 a *Polyporus pinsitus* laccase,
- a *Myceliophthora thermophila* laccase
- a *Myceliophthora thermophila* T1 laccase variant,
- a *Rhus vernicifera* laccase
- a *Rhizoctonia solani* laccase
- 10 a *Scytalidium thermophila* laccase

#### Hair dyeing

1 gram white De Meo hair tresses were used.

- 4 ml dye precursor solution (including modifier) was mixed
- 15 with 1 ml laccase on a Whirley mixer, applied to the hair tresses and incubated at 30°C for 60 minutes.

The hair tresses were then rinsed with running water, washed with shampoo, rinsed with water, combed, and air dried.

- a\*, b\* and L\* were determined on the Chroma Meter and  $\Delta E^*$
- 20 was then calculated.

Hair tress samples treated without enzyme were used as a blind.

The result of the test is displayed in figure 1.

#### 25 **Example 2**

##### Wash stability

- Tresses of white De Meo hair (1 gram) were used for testing
- of the wash stability of hair dyed using the *Myceliophthora thermophila* T-variant laccase and the *Polyporus pinsitus*
- 30 laccase.

Oxidative hair dyeing was carried out as described in Example 1, except that p-phenylene-diamine (PPD) were used as the dye precursor and no modifiers were used.

#### 35 Hair wash

The dyed hair tresses were wetted and washed for 15 seconds with 50 ml of commercial shampoo, and rinsed with water for 1

minute and air dried. The hair tresses were washed up to 18 times.

Then  $a^*$ ,  $b^*$  and  $L^*$  were determined on the Chroma Meter and  $\Delta E^*$  values were then calculated.

- 5 Hair tress samples treated without enzymes were used as blinds.

The result of the test is displayed in figure 2.

### Example 3

#### 10 Fastness of hair dyeing

Tresses of white De Meo hair (1 gram) were used for testing fastness (speed) of hair dyeing using the *Myceliophthora thermophila* T1 variant laccase and the *Polyporus pinsitus* laccase.

- 15 p-phenylene-diamine (PPD) was used as the dye precursor and no modifiers were used.

4 ml dye precursor solution was mixed with 1 ml laccase on a Whirley mixer, applied to the hair tresses and incubated at 30°C for 10, 20, 30, 40, 50 and 60 minutes, respectively.

- 20 The hair tresses were then rinsed with running water, washed with shampoo, rinsed with running water, combed, and air dried.

$a^*$ ,  $b^*$  and  $L^*$  were determined on the Chroma Meter for each incubation time and the  $\Delta E^*$ -values were then calculated.

- 25 Hair tress samples treated without enzymes for 60 minutes were used as blinds.

The result of the test is displayed in figure 3.

### Example 4

#### Dyeing effect of *Myceliophthora thermophila* T1 variant laccase

- 30 The dyeing effect of *Myceliophthora thermophila* T1 variant laccase were compared with the *Polyporus pinsitus* laccase using 0.1% w/w p-phenylene-diamine, 0.1% w/w p-touylene-diamine, 0.1% w/w chloro-p-phenylene-diamine, 0.1% w/w p-aminophenol, 0.1% w/w o-aminophenol and 0.1% w/w 3,4 diaminotoluene, respectively, as dye precursors.

35 The *Polyporus pinsitus* laccase were applied in a concentration of 10 LACU/ml while the *Myceliophthora*

*thermophila* T1 variant laccase was applied in a concentration of only 1 LACU/ml.

1 gram white De Meo hair tresses were used.

4 ml dye precursor solution was mixed with 1 ml laccase on a  
5 Whirley mixer, applied to the hair tresses and incubated at 30°C for 60 minutes.

The hair tresses were then rinsed with running water, washed with shampoo, rinsed with running water, combed, and air dried.

The a\*, b\* and L\* were determined on the Chroma Meter and  
10 the  $\Delta E^*$  values were then calculated.

Hair tress samples treated without enzyme were used as blinds.

The result of the test is displayed in Table 1.

15 Table 1

Sample	<i>Polyporus pinsitus</i> laccase $\Delta E^*$	<i>Myceliophthora thermophila</i> T1 variant laccase $\Delta E^*$
p-phenylene-diamine blind	9.7	10.9
p-phenylene-diamine + laccase	52.7	52.9
p-toluylene-diamine blind	16.1	18.6
p-toluylene-diamine + laccase	39.1	38.2
chloro-p-phenylene-diamine blind	2.6	4.0
chloro-p-phenylene-diamine + laccase	40.5	39.2
p-aminophenol blind	6.2	7.0
p-aminophenol + laccase	32.4	28.1
o-amonophenol blind	5.6	6.4
o-amonophenol + laccase	22.9	22.0
3,4-diaminotoluene blind	3.4	2.6
3,4-diaminotoluene + laccase	36.5	42.2

As can be seen from Table 1 compositions comprising the *Myceliophthora thermophila* T1 laccase variant dyes the hair as good as the *Polyporus pinsitus* laccase even though

concentration of the *Polyporus pinsitus* laccase is 10 time higher.

Example 5

5 Dose-response dyeing effect of *M. thermophila* laccase

The dyeing effect of *M. thermophila* laccase were tested using concentration between 0.0001 to 0.5 mg enzyme protein per ml dyeing composition of laccase. 0.1% w/w p-toluylene-diamine (PTD) was used as the dye precursor.

- 10 The same dyeing procedure as described in Example 1 was used.  
The result of the tests are displayed in Figure 4.

## SEQUENCE LISTING

## (1) GENERAL INFORMATION:

5

## (i) APPLICANT:

(A) NAME: Novo Nordisk A/S  
 (B) STREET: Novo Alle  
 (C) CITY: Bagsvaerd  
 (D) COUNTRY: Denmark  
 (E) POSTAL CODE (ZIP): DK-2880  
 (F) TELEPHONE: +45 4444 8888  
 (G) TELEFAX: +45 4449 3256

10

15

(ii) TITLE OF INVENTION: Laccases with improved dyeing properties

(iii) NUMBER OF SEQUENCES: 2

20

## (v) COMPUTER READABLE FORM:

(A) MEDIUM TYPE: Floppy disk  
 (B) COMPUTER: IBM PC compatible  
 (C) OPERATING SYSTEM: PC-DOS/MS-DOS  
 (D) SOFTWARE: PatentIn Release #1.0, Version #1.30

25

## (2) INFORMATION FOR SEQ ID NO:1:

## (i) SEQUENCE CHARACTERISTICS:

30

(A) LENGTH: 3192 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

35

(ii) MOLECULE TYPE: DNA (genomic)

## (ix) FEATURE:

(A) NAME/KEY: CDS  
 (B) LOCATION: join(586..831, 917..994, 1079..1090, 1193..1264, 1337..2308, 2456..2524, 2618..3028)

40

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

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	TCATCGAGCG AGTGATCTCC ACCACCCAGA AGGGAGGGGG GATGCGCGCA TGCTCCAACA	180
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	GGACCGGCTC CTTTCACCCC CGCGTCCTCC GGAGGATTGA GTCACGATAT TTCGGGATGT	300
	GGGAAGGGGG AGAGAAAGGA GGGGGGAGGG GCGGAAACAT GTTGGATACG AGCTGCGCCC	360
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	CTCCTTCTCG TCGTCGACTT GTCTCAGGTT CTCTCTCTCG TCCACACCAA GCCAGTCTTG	480
	CCTGAGCCAC CTGAGCCACC TTCAACTCAT CATCTTCAGT CAAGTCGTTC ATTGACATTG	540
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	Met Lys Ser	
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65	TTC ATC AGC GCC GCG ACG CTT TTG GTG GGC ATT CTC ACC CCT AGC GTT	642
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	5 10 15	

20

	GCT GCT GCC CCT CCA TCC ACC CCT GAG CAG CGC GAC CTG CTC GTC CCG	690
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5	ATC ACG GAG AGG GAG GAG GCA GCC GTG AAG GCT CGC CAG CAG AGC TGC	738
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	40 45 50	
10	AAC ACC CCC AGC AAC CGG GCG TGC TGG ACT GAC GGA TAC GAC ATC AAC	786
	Asn Thr Pro Ser Asn Arg Ala Cys Trp Thr Asp Gly Tyr Asp Ile Asn	
	55 60 65	
15	ACC GAC TAC GAA GTG GAC AGC CCG GAC ACG GGT GTT GTT CCG CCG	831
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	70 75 80	
	GTGAGTGCTC TCGTTAATTA CGCTTCGGCG AGTTGCGCAG ATATATTAAA TACTGCAAAC	891
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	85 90	
25	AAC TGG ACC GGA CCT GAT GGC GTC GTC AAG GAG AAG GTC ATG CTG GTT	991
	Asn Trp Thr Gly Pro Asp Gly Val Val Lys Glu Lys Val Met Leu Val	
	95 100 105	
	AAC GTACGGCACC CCTTTTCTTG TCCTAGGATC TGGGTGATGT GCGTCGTTGC	1044
30	Asn	
	CCCTGAGAGA GACTGACCGA GCCTTTGGCT GCAG AAT ACT ATA ATC GTAATTAATT	1100
	Asn Ser Ile Ile	
	110	
35	ATACCGCCCT GCCTCCAGCA GCCCCAGCAG CTCGAGAAGG GTATCTGAAG TTAGTCAGGC	1160
	CTGCTGACCT GACCGGGGCC AACCCACCAT AG GGA CCA ACA ATC TTT GCG GAC	1213
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40	115	
	TGG GGC GAC ACG ATC CAG GTA ACG GTC ATC AAC AAC CTC GAG ACC AAC	1261
	Trp Gly Asp Thr Ile Gln Val Thr Val Ile Asn Asn Leu Glu Thr Asn	
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45	GGC GTATGTCTGC TGCTTGCTCT CTTGCTCTCC TCGTCCGCGA CTAATAATAA	1314
	Gly	
50	TATCAACTCG TGTGAAAAC AG ACG TCG ATC CAC TGG CAC GGA CTG CAC CAG	1366
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	140 145	
55	AAG GGC ACC AAC CTG CAC GAC GGC GCC AAC GGT ATC ACC GAG TGC CCG	1414
	Lys Gly Thr Asn Leu His Asp Gly Ala Asn Gly Ile Thr Glu Cys Pro	
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	180 185 190	
65	GGC GTG GTC GGG GCC ATT CAG ATC AAC GGG CCG GCC TCG CTG CCG TAC	1558
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	195 200 205 210	

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	215 220 225	
5	GCC GAC GAG CTG GTG GAA CTC ACC AAG AAC TCG GGC GCG CCC TTC AGC	1654
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	230 235 240	
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	AAC CAC ACC ATG ACC ATC ATC GCC GCC GAC ATG GTG CCC GTC AAC GCC	1846
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30	GTC ATC GAA GCC AGC CGA ACG CCC GGG AAC TAC TGG TTT AAC GTC ACA	1942
	Val Ile Glu Ala Ser Arg Thr Pro Gly Asn Tyr Trp Phe Asn Val Thr	
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35	TTT GGC GGC GGC CTG CTC TGC GGC GGC TCC AGG AAT CCC TAC CCG GCC	1990
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	Ala Ile Phe His Tyr Ala Gly Ala Pro Gly Gly Pro Pro Thr Asp Glu	
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	Gly Lys Ala Pro Val Asp His Asn Cys Leu Asp Leu Pro Asn Leu Lys	
	375 380 385	
45	CCC GTC GTG GCC CGC GAC GTG CCC CTG AGC GGC TTC GCC AAG CGG CCC	2134
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	390 395 400	
50	GAC AAC ACG CTC GAC GTC ACC CTC GAC ACC ACG GGC ACG CCC CTG TTC	2182
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	405 410 415	
55	GTC TGG AAG GTC AAC GGC AGC GCC ATC AAC ATC GAC TGG GGC AGG CCC	2230
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60	GTC GTC GAC TAC GTC CTC ACG CAG AAC ACC AGC TTC CCA CCC GGG TAC	2278
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	AAC ATT GTC GAG GTG AAC GGA GCT GAT CAG GTAAGAAAAA GGGGACCGCA	2328
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	455 460	
65	GGGGTGCTGC TGCAAGTACA CCTTGCTCGC CCTCTGTTC TTCCTTAATA ACTACCTCCC	2388
	AACCCTCCCC CCTAATTAAT TCACTTTAA GGGCGATCAA GACTGACCGA GCCCCCTCTC	2448

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					465						470						
5																	
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10	475					480											
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	TAACAAAAAA	AAG	GGC	CAC	GAC	TTT	TAC	GTG	CTG	GGC	CGC	TCG	CCC	GAC		2653	
15			Gly	His	Asp	Phe	Tyr	Val	Leu	Gly	Arg	Ser	Pro	Asp			
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	GAG	TCG	CCG	GCA	TCC	AAC	GAG	CGG	CAC	GTG	TTC	GAT	CCG	GCG	CGG	GAC	2701
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25	CTG	CCG	GCG	TTC	GGG	TGG	GTG	GTG	CTG	GCC	TTC	CGG	GCC	GAC	AAC	CCG	2797
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30	GGC	GCC	TGG	CTG	TTC	CAC	TGC	CAC	ATC	GCC	TGG	CAC	GTC	TCG	GGC	GGC	2845
	Gly	Ala	Trp	Leu	Phe	His	Cys	His	Ile	Ala	Trp	His	Val	Ser	Gly	Gly	
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	TCG	GAC	GCC	GAC	GCC	GAC	GAC	CTC	GAC	CGC	CTC	TGC	GCC	GAC	TGG	CGC	2941
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	GGTGTGTGAT	CGGGTAAATA	TTATCAAGAG	ATCT													3192
55																	

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:

- SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 620 amino acids
  - (B) TYPE: amino acid
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

Met Lys Ser Phe Ile Ser Ala Ala Thr Leu Leu Val Gly Ile Leu Thr



23

	1	5	10	15
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5	Leu Val Pro	Ile Thr Glu Arg	Glu Glu Ala Ala	Val Lys Ala Arg Gln
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	Asp Ile Asn	Thr Asp Tyr	Glu Val Asp	Ser Pro Asp Thr Gly Val Val
	65	70		75
15	Arg Pro Tyr	Thr Leu Thr	Glu Val Asp	Asn Trp Thr Gly Pro
		85	90	95
	Asp Gly Val	Val Lys Glu Lys	Val Met Leu Val	Asn Asn Ser Ile Ile
		100	105	110
20	Gly Pro Thr	Ile Phe Ala Asp	Trp Gly Asp Thr	Ile Gln Val Thr Val
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	Ile Asn Asn	Leu Glu Thr	Asn Gly Thr	Ser Ile His Trp His Gly Leu
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	Pro Tyr Asp	Thr Asp Leu	Gly Val Phe	Pro Ile Ser Asp Tyr Tyr Tyr
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	225	230		235
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50	Arg Leu Arg	Leu Ile Asn	Thr Ser Val	Glu Asn His Phe Gln Val Ser
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	Leu Val Asn	His Thr Met	Thr Ile Ile	Ala Ala Asp Met Val Pro Val
55	290		295	300
	Asn Ala Met	Thr Val Asp	Ser Leu Phe	Leu Gly Val Gly Gln Arg Tyr
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60	Asp Val Val	Ile Glu Ala	Ser Arg Thr	Pro Gly Asn Tyr Trp Phe Asn
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	Val Thr Phe	Gly Gly Gly	Leu Leu Cys	Gly Gly Ser Arg Asn Pro Tyr
		340	345	350
65	Pro Ala Ala	Ile Phe His	Tyr Ala Gly	Ala Pro Gly Gly Pro Pro Thr
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Asp Glu Gly Lys Ala Pro Val Asp His Asn Cys Leu Asp Leu Pro Asn  
 370 375 380  
 5 Leu Lys Pro Val Val Ala Arg Asp Val Pro Leu Ser Gly Phe Ala Lys  
 385 390 395 400  
 Arg Pro Asp Asn Thr Leu Asp Val Thr Leu Asp Thr Thr Gly Thr Pro  
 405 410 415  
 10 Leu Phe Val Trp Lys Val Asn Gly Ser Ala Ile Asn Ile Asp Trp Gly  
 420 425 430  
 Arg Pro Val Val Asp Tyr Val Leu Thr Gln Asn Thr Ser Phe Pro Pro  
 435 440 445  
 15 Gly Tyr Asn Ile Val Glu Val Asn Gly Ala Asp Gln Trp Ser Tyr Trp  
 450 455 460  
 20 Leu Ile Glu Asn Asp Pro Gly Ala Pro Phe Thr Leu Pro His Pro Met  
 465 470 475 480  
 His Leu His Gly His Asp Phe Tyr Val Leu Gly Arg Ser Pro Asp Glu  
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 25 Ser Pro Ala Ser Asn Glu Arg His Val Phe Asp Pro Ala Arg Asp Ala  
 500 505 510  
 Gly Leu Leu Ser Gly Ala Asn Pro Val Arg Arg Asp Val Thr Met Leu  
 515 520 525  
 30 Pro Ala Phe Gly Trp Val Val Leu Ala Phe Arg Ala Asp Asn Pro Gly  
 530 535 540  
 35 Ala Trp Leu Phe His Cys His Ile Ala Trp His Val Ser Gly Gly Leu  
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 Gly Val Val Tyr Leu Glu Arg Ala Asp Asp Leu Arg Gly Ala Val Ser  
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 580 585 590  
 Tyr Trp Pro Thr Asn Pro Tyr Pro Lys Ser Asp Ser Gly Leu Lys His  
 595 600 605  
 45 Arg Trp Val Glu Glu Gly Glu Trp Leu Val Lys Ala  
 610 615 620

## INDICATIONS RELATING TO A DEPOSITED MICROORGANISM

(PCT Rule 13 bis)

A. The indications made below relate to the microorganism referred to in the description on page <u>13</u> , line <u>4-13</u> .	
B. IDENTIFICATION OF <span style="float: right;">Further deposits are identified on an additional sheet <input type="checkbox"/></span>	
Name of depository institution Agricultural Research Service Patent Culture Collection (NRRL)	
Address of depository institution (including postal code and country)  Northern Regional Research Center 1815 University Street Peoria, IL 61604, US	
Date of deposit 25 May 1994	Accession Number NRRL B-21261
C. ADDITIONAL INDICATIONS (leave blank if not applicable) <span style="float: right;">This information is continued on an additional sheet <input type="checkbox"/></span>	
In respect of those designations in which a European and/or Australia Patent is sought, during the pendency of the patent application, a sample of the deposited microorganism is only to be provided to an independent expert nominated by the person requesting the sample (Rule 28(4) EPC/Regulation 3.25 of Australia Statutory Rule 1991 No. 71).	
D. DESIGNATED STATES FOR WHICH INDICATIONS ARE MADE (if the indications are not for all designated States)	
E. SEPARATE FURNISHING OF INDICATIONS (leave blank if not applicable)	
The indication listed below will be submitted to the International Bureau Later (specify the general nature of the indications e.g. "Accession Number of Deposit")    	

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## PATENT CLAIMS

1. A dyeing composition comprising
  - a) above 0 to 1 mg enzyme protein per ml dyeing composition of microbial laccase,
  - b) one or more dye precursor, and
  - c) optionally one or more dye modifiers.
2. The dyeing composition according claims 1, wherein the laccase is presents in a concentration of from 0.0001 to 1 mg/ml, preferably 0.001 to 0.8 mg/ml, more preferred 0.002 to 0.5 mg/ml, even more preferred 0.003 to 0.2 mg/ml, especially 0.004 to 0.1 mg enzyme protein/ml dyeing composition.
3. The dyeing composition according to claims 1 and 2, wherein said microbial laccase is of filamentous fungus origin.
4. The dyeing composition according to claims 1 and 2, wherein the laccase is derived from a strain of the genus *Myceliophthora*, in particular a strain of species *Myceliophthora thermophila*, such as *Myceliophthora thermophila* NRRL B 21261, or variants thereof, such as the T1 variant.
5. The dyeing composition according to claim 4, wherein the laccase is encoding by the sequence shown in SEQ ID NO 1.
6. The dyeing composition according to claims 4 and 5, wherein the laccase is present in a concentration of from above 0 to 1 mg/ml, preferably 0.0001 to 0.1 mg/ml, more preferably 0.0005 to 0.05 mg/ml, especially 0.001 to 0.01 mg enzyme protein/ml dyeing composition.
7. The dyeing composition according to any of claims 1 to 6, comprising a dye precursor selected from the group comprising p-phenylene-diamine (PPD), p-toluylene-diamine (pTD), chloro-p-phenylenediamine, p-aminophenol, o-aminophenol, 3,4-diaminotoluene, 2-methyl-1,4-diaminobenzene, 4-methyl-o-phenylenediamine, 2-methoxy-p-phenylenediamine, 2-chloro-1,4-diaminobenzene, 4-amino diphenylamine, 1-amino-4- $\beta$ -methoxyethylamino-benzene, 1-amino-4-bis-( $\beta$ -hydroxyethyl)-amonibenzene, 1-3-diaminobenzene, 2-methyl-1,3-diamino-benzene, 2,4-diaminotoluene, 2,6-diaminopyridine, 1-hydroxy-2-amino-benzene, 1-hydroxy-3-amino-benzene, 1-methyl-2-hydroxy-4-amino-benzene, 1-methyl-2-hydro-

xy-4- $\beta$ -hydroxyethylamino-benzene, 1-hydroxy-4-amino-benzene, 1-hydroxy-4-methylamino-benzene, 1-methoxy-2,4-diamino-benzene, 1-ethoxy-2,3-diamino-benzene, 1- $\beta$ -hydroxyethyloxy-2,4-diamino-benzene, phenazines, such as 4,7-phenazinedicarboxylic acid, 2,7-phenazinedicarboxylic acid, 2-phenazinecarboxylic acid, 2,7-diaminophenazine, 2,8-diaminophenazine, 2,7-diamino-3,8-dimethoxyphenazine, 2,7-diamino-3-methoxyphenazine, 2,7-diamino-3-methoxyphenazine, 3-dimethyl 2,8-phenazinediamine, 2,2'-[(8-amino-7-methyl-2-phenazinyl)imino]bis-ethanol, 2,2'-[(8-amino-7-methoxy-2-phenazinyl)imino]bis-ethanol, 2,2'-[(8-amino-7-chloro-2-phenazinyl)imino]bis-ethanol, 2-[(8-amino-7-methyl-2-phenazinyl)amino]-ethanol, 2,2'-[(8-amino-2-phenazinyl)imino]-bis-ethanol, 3-amino-7-(dimethylamino)-2,8-dimethyl-5-phenyl-chloride, 9-(diethylamino)-benzo[a]phenazine-1,5-diol, N-[8-(diethylamino)-2-phenazinyl]-methanesulfonamide, N-(8-methoxy-2-phenazinyl)-methanesulfonamide, N,N,N',N'-tetramethyl-2,7-phenazinediamine, 3,7-dimethyl-2-phenazinamine, p-amino benzoic acids, such as p-amino benzoic acid ethyl, p-amino benzoic acid glycerid, p-amino benzoic acid isobutyl, p-dimethylamino benzoic acid amil, p-dimethylamino benzoic acid octyl, p-diethoxy amino benzoic amil, p-dipropoxy amino benzoic acid ethyl, acetylsalicylic acid, isatin derivatives, such as 2,3-diamino benzoic acid.

8. The dyeing composition according to any of claims 1 to 7, comprising a dye modifier selected from the group comprising m-phenylene-diamine, 2,4-diaminoanisole, 1-hydroxynaphthalene( $\alpha$ -naphthol), 1,4-dihydroxybenzene(hydroquinone), 1,5-dihydroxynaphthalene, 1,2-dihydroxybenzene(pyrocatechol), 1,3-dihydroxybenzene (resorcinol), 1,3-dihydroxy-2-methylbenzene, 1,3-dihydroxy-4-chlorobenzene (4-chlororesorcinol), 1,2,3-trihydroxybenzene, 1,2,4-trihydroxybenzene, 1,2,4-trihydroxy-5-methylbenzene, 1,2,4-trihydroxytoluene.

9. Use of the composition according to claim 1 to 8 for permanent dyeing of keratinous fibres, such as hair, fur, hide or wool.

10. A method for dyeing keratinous fibres comprising contacting a dyeing composition according to claims 1 to 8 to

the keratinous fibres under suitable conditions and for a period of time sufficient to permit oxidation of the dye precursor into a coloured compound.

11. The method according to claim 10, wherein the dyeing  
5 procedure is carried out at a pH in the range from 3 to 10, preferably 5 to 9, especially 6 to 8.

12. The method wherein according to claims 10 and 11,  
wherein the procedure is carried out for a period of time  
between 10 and 60 minutes, preferably 15 to 50 minutes,  
10 especially 20 to 40 minutes.

1/4

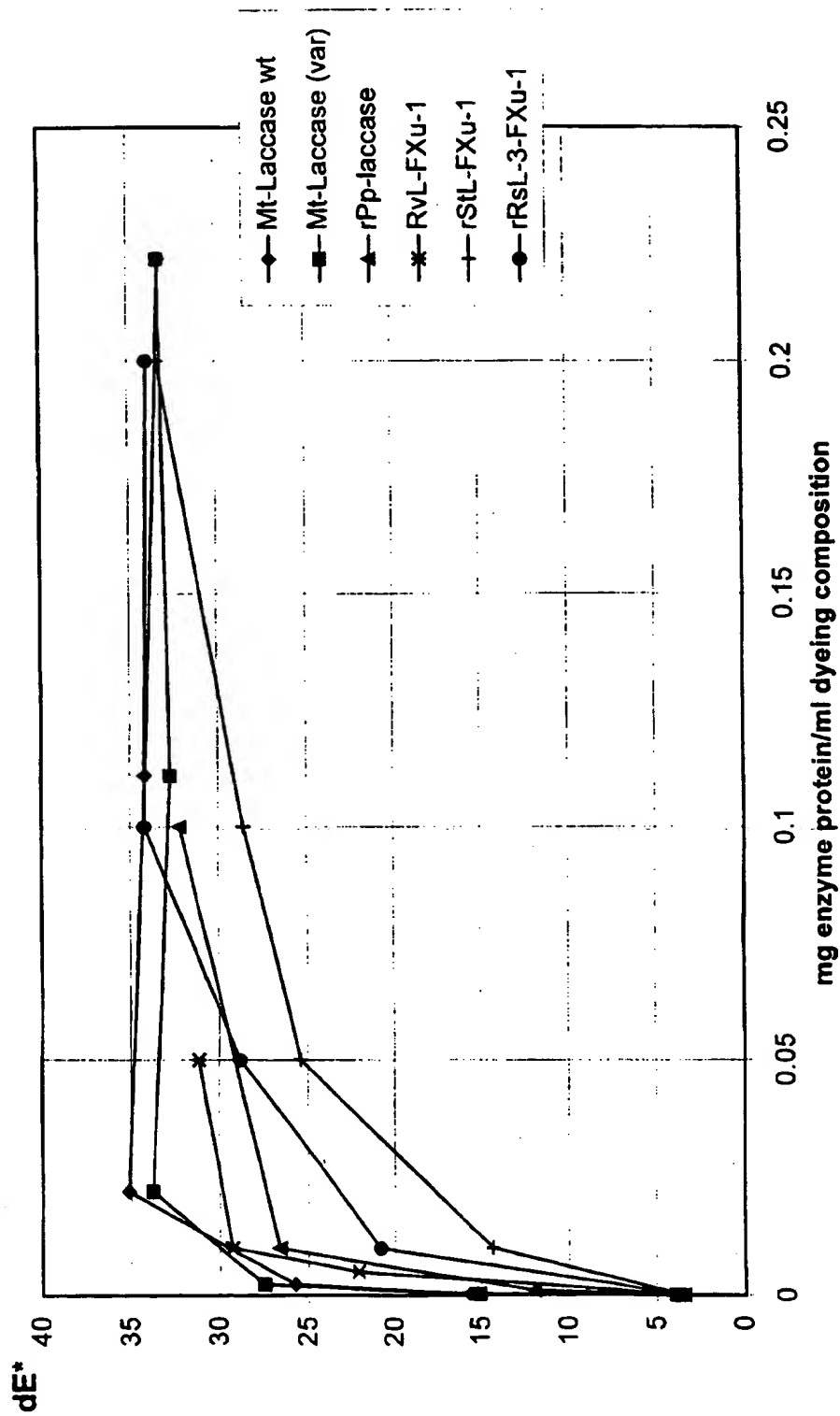
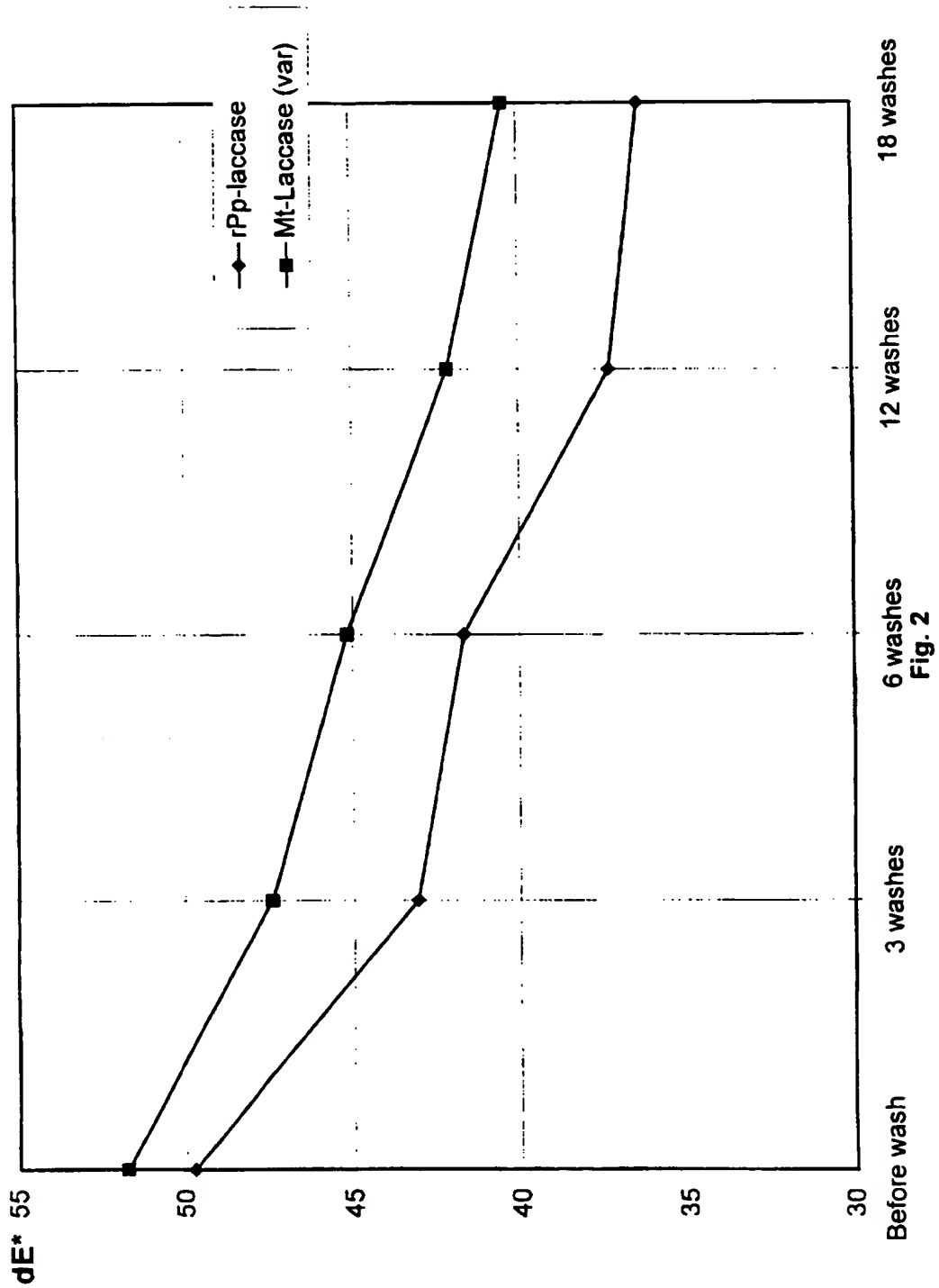


Fig. 1

2/4





3/4

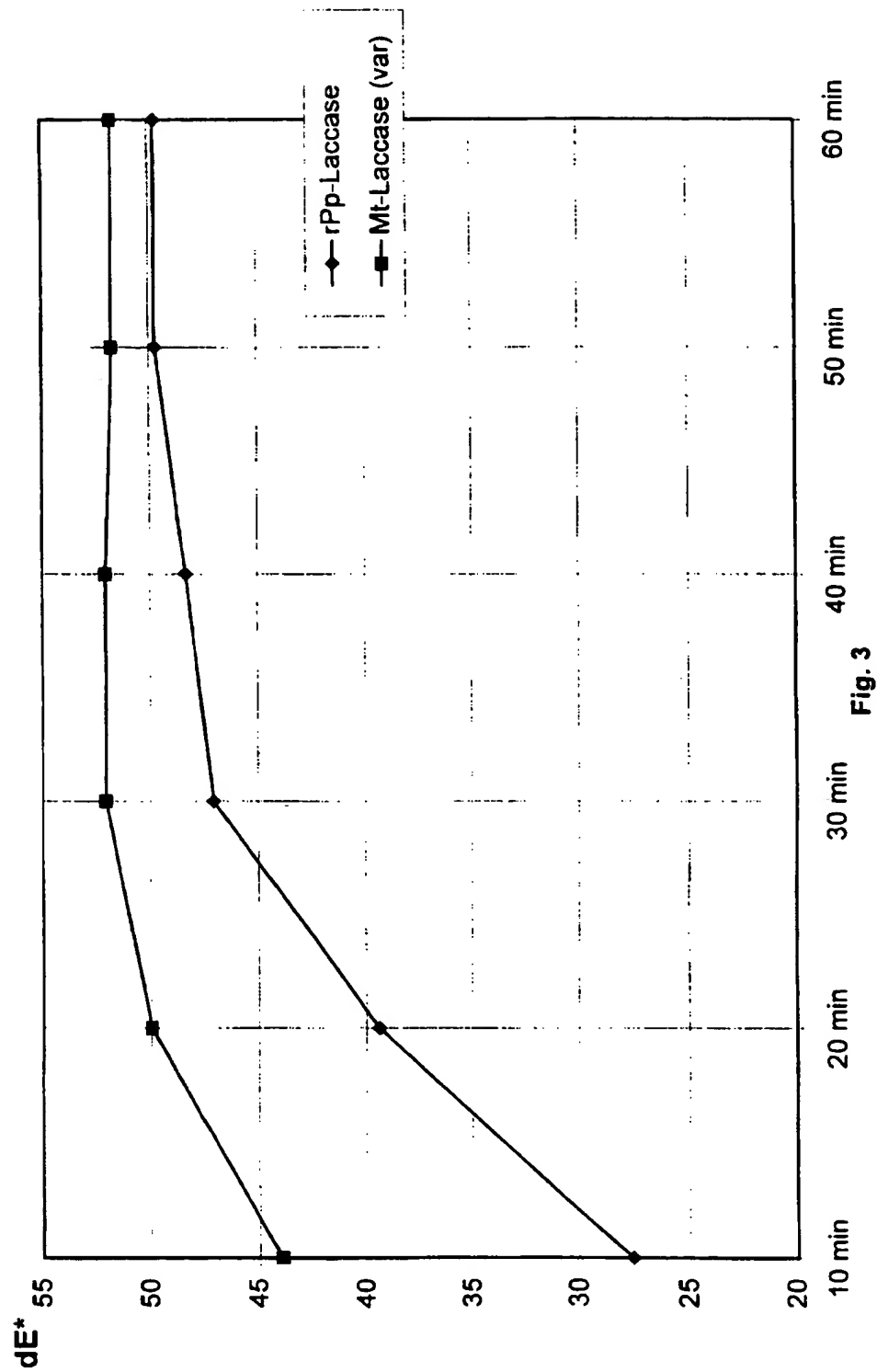
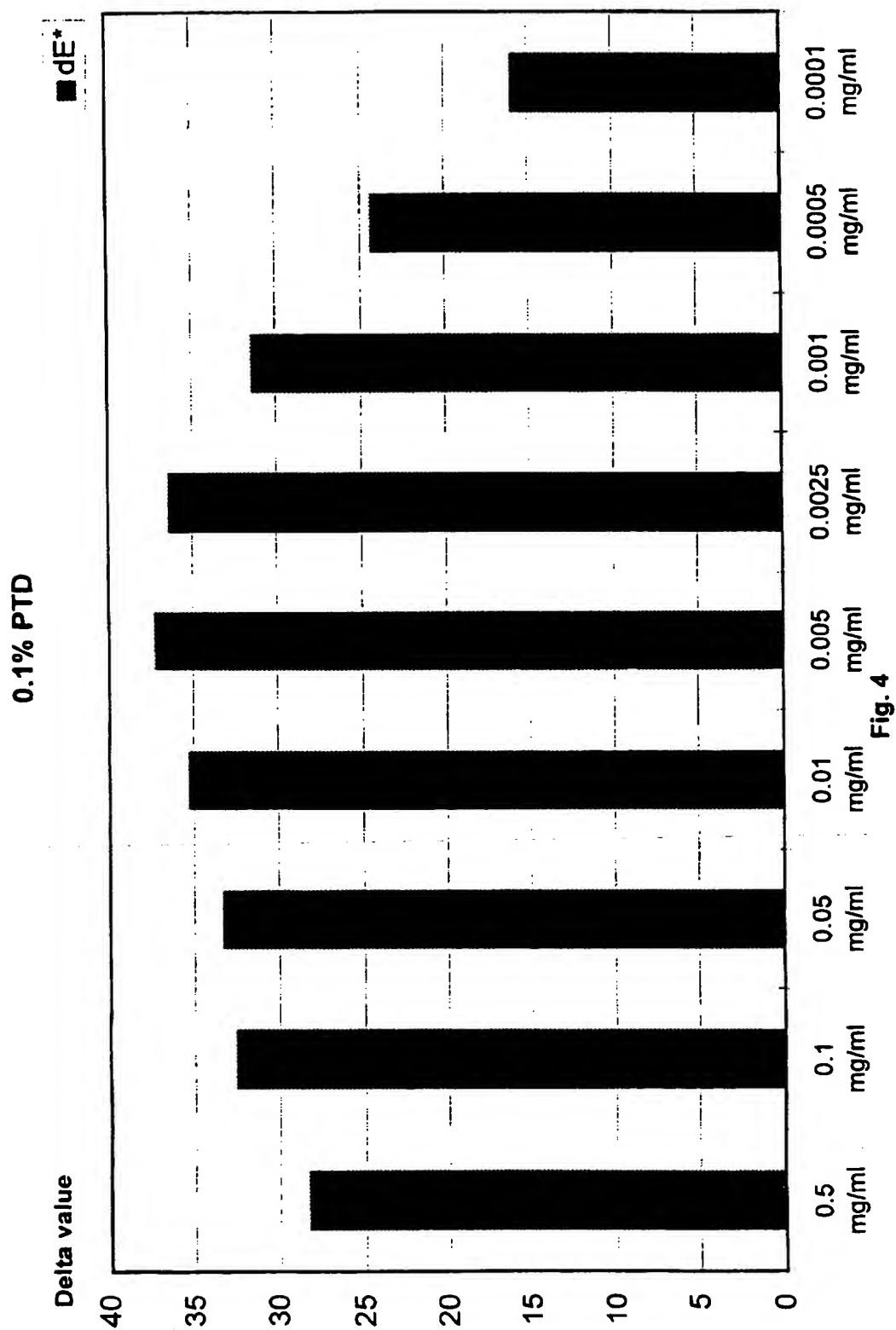


Fig. 3

4/4



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 96/00499

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C09B 67/00, A61K 7/13

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C09B, A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 9533836 A1 (NOVO NORDISK BIOTECH, INC.), 14 December 1995 (14.12.95), claims 31-42; page 16, line 12 - page 17, line 27; page 34, line 20 - page 36	1-12
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P,X	WO 9533837 A1 (NOVO NORDISK BIOTECH, INC.), 14 December 1995 (14.12.95), claims 28, 29; page 15, line 34 - page 16, line 2	1-3
P,A		4-12
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X	EP 0504005 A1 (PERMA SOCIETE ANONYME), 16 Sept 1992 (16.09.92)	1-3
A		4-12
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☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

- \* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "B" earlier document but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
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- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "Z" document member of the same patent family

Date of the actual completion of the international search

28 February 1997

Date of mailing of the international search report

01-03-1997

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 96/00499

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	STN International, File CAPLUS, CAPLUS accession no. 1991:498981, Saruno, Rinjiro: "Hair- dyeing preparations containing melanin or other poly- phenol pigments and manufacture of the pigments"; & JP,A,03077813, 910403	1-3
X	STN International, File CAPLUS, CAPLUS accession no. 1995:974547, Chivukula, Muralikrishna et al: "Phenolic azo dye oxidation by laccase from Pyricularia oryzae"; & Appl. Environ. Microbiol. (1995), 61(12), 4374-77	1-3
A	US 3251742 A (SAUL SOLOWAY), 17 May 1966 (17.05.66)	1-12
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A	DE 4314317 A1 (HENKEL KGAA), 3 November 1994 (03.11.94)	7
A	WO 9400100 A1 (L'OREAL), 6 January 1994 (06.01.94)	7
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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

03/02/97

International application No.  
PCT/DK 96/00499

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